Technical Report 1163

An Assessment of the Virtual–Integrated MOUT Training System (V-IMTS)

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U.S. Army Research Institute

June 2005

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14. ABSTRACT *(Maximum 200 words)*:
This report describes an assessment of the Virtual Integrated Military Operations in Urban Terrain (MOUT) Training System (V-IMTS). V-IMTS was a short-term project to speed the transition to field use of virtual simulation technology that specifically considered the integration of live and virtual training. A deployable shelter containing simulators for an Infantry squad was installed at a live MOUT site. Twenty-seven Soldiers from three squads completed two live scenarios separated by two, three, or six virtual scenarios. They then completed questionnaires to indicate how well they could perform combat activities in the simulators, and the extent of their skill improvement. Higher rated activities included outdoor movement, identification of types of people and tactically significant areas, and individual weapons use. Lower rated activities included maneuver indoors and identifying the source and type of fire. The Soldiers and their platoon leadership believed that they received effective training. Precision movement, capture and transmission of voice communications, and representation of battlefield sounds were identified as the highest priority items for improvement. It was concluded that virtual simulation technology can provide additional practice in urban operations to supplement the use of a live MOUT site. It appears to be best suited for training mission planning, situation assessment, and communication and coordination.

15. SUBJECT TERMS
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Personnel Performance
and Training Technology

FOREWORD

The U.S. Army requires dismounted Soldier simulation capabilities to meet multiple needs. The first need is for simulations that allow dismounted leaders, Soldiers, and units to train effectively even if they do not have frequent opportunity to participate in high fidelity field training exercises. Live training opportunities are becoming scarcer due to the challenges of cost, time, environmental, and safety constraints. In addition, leaders, Soldiers and units need effective mission rehearsal tools that prepare them for specific combat missions in all types of terrain. Finally, U.S. Army decision makers need inexpensive and high fidelity prototyping and testing systems that will allow them to explore and evaluate potential doctrine, organization, equipment, and Soldier characteristics. These needs are very important today. They are likely to become more important as the Army transformation continues.

The U.S. Army is committed to virtual training in the aviation, armor, and mechanized Infantry communities through the use of the Aviation Combined Arms Tactical Trainer and the Close Combat Tactical Trainer. Virtual environment technologies have the potential to provide training, mission rehearsal, and experimentation capabilities for dismounted Soldiers and leaders. However, until now there has been no managed program to integrate and package available virtual training technologies for transition to the field. In November 2003, the Product Manager, Ground Combat Tactical Training (PM, GCTT), a component of the Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI), with technical support from the U.S. Army Research, Development, and Engineering Command, Simulation and Training Technology Center (RDECOM STTC) received funds from the Defense Acquisition Challenge Program for a short-term project to speed the transition of virtual simulation technology for dismounted Soldiers from the research and development community to the training environment. The program was expected to provide a virtual training system that would lay the foundation for rapid technology insertion into the three major acquisition programs: the Integrated MOUT Training System, the Virtual Emergency Response Training System, and the Soldier Combined Arms Tactical Trainer. This transition effort was planned to include an assessment of the training technology as used by Soldiers in a realistic training situation. The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) was asked to support the planning and conduct of this assessment.

The ARI work was performed as part of Army Technology Objective IV.HS.2003.06 Training Small Unit Leaders and Teams. PM, GCTT used preliminary results in a briefing for the CG, 101st Division in October 2004. A draft of this report was provided to PM, GCTT and RDECOM STTC in January, 2005. The results of this program will be used to influence future dismounted Soldier simulation development efforts.

MICHELLE SAMS
Technical Director

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- MAJ Theodore M. Perryman and Ms. Debra Marsden, Project Manager, Ground Combat Training Systems, who provided overall program management support.

- Mr. James Grosse, Mr. Brian Comer, and Ms. Michelle Mayo, Research, Development, and Engineering Command, Simulation and Training Technology Center, who provided technical direction and hands-on implementation.

- Mr. Larry Ziock, Institute for Simulation and Training, who provided the military expertise.

- The Soldiers from the 101st Division, Air Assault, who participated enthusiastically and gave us their open and honest feedback.

AN ASSESSMENT OF THE VIRTUAL–INTEGRATED MOUT TRAINING SYSTEM (V-IMTS)

EXECUTIVE SUMMARY

Research Requirement:

In November 2003, the Product Manager, Ground Combat Tactical Training (PM, GCTT), a component of the Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI), received funds from the Defense Acquisition Challenge Program for a short-term project to speed the transition of virtual simulation technology for dismounted Soldiers from the research and development community to the training environment. This dual-use technology could be used to immerse a warfighter or an emergency responder into a networked simulation, providing a training capability for homeland security and urban operations. The program, on which the U.S. Army Research, Development, and Engineering Command, Simulation and Training Technology Center (RDECOM STTC) provided the technical lead, was expected to provide a virtual training system that would lay the foundation for rapid technology insertion into three major acquisition programs: the Integrated MOUT Training System, the Virtual Emergency Response Training System, and the Soldier Combined Arms Tactical Trainer. This program was planned to include an assessment of the training technology as used by Soldiers in a realistic training situation.

Procedure:

The assessment was conducted at the Cassidy Combined Arms Collective Training Center, Fort Campbell, KY. A shelter containing nine virtual simulators was deployed next to the control building at the site. Twenty-seven Soldiers from three squads completed two live scenarios separated by two, three, or six virtual scenarios. The scenarios consisted of multiple variants of two missions: Search and Cordon a Building, and Attack/Assault a Building. At the conclusion of their training, Soldiers completed questionnaires to provide information about how well they could perform combat activities in the simulators, the effectiveness of the After Action Reviews (AARs), side effects, and perceived training effectiveness.

Findings:

The activities which the Soldiers indicated they could perform best in the simulators included outdoor movement, identification of types of people (civilians, non-combatants within a room, enemy Soldiers), identification of tactically significant areas (sectors of observation and responsibility), and individual weapons use (but not grenades). Poorly rated activities included maneuver indoors (close to others, past furniture, close to walls, around objects, past other personnel, around corners, through doorways, up and down stairs), and identifying the source and type of fire (enemy or friendly), either by auditory or visual cues.

It was clear from the questionnaires, interviews, and informal comments made during the assessment that the Soldiers and their Platoon leadership believed that they received effective training. Both the squad and fire team leaders and the Soldiers reported about the same amount of overall improvement, although the skills on which they reported improving the most differed. Leaders reported the greatest improvement on: control of squad/fire team movement during the assault, assess the tactical situation, plan a tactical operation, and coordinate activities with your chain of command. Soldiers reported the most improvement on: plan a tactical operation, coordinate activities with your chain of command, and communicate with members of your team or squad. These effectiveness data should be viewed with caution. There is no objective data that the skills of the Soldiers actually improved, only their subjective reports that it did, collaborated by the impressions of their Leaders.

High priority items for improvement were identified. The top priority item for improvement is precision movement. Generally, precise motion, either body movement in confined areas or weapons aiming, could not be performed well. Second, a method needs to be developed to transmit and capture voice communication, both face-to-face and radio. Face–to–face communication should include that between Soldiers, enemies and civilians, as well as within the unit itself. Third, battlefield sounds need to be represented. With these improvements, it should be possible to investigate the issue of training effectiveness more rigorously.

Virtual simulation technology is sufficiently mature to provide a valuable addition to the dismounted Soldier training mix. It can provide additional practice in urban operations to supplement the use of a live MOUT site. It appears to be best suited for training mission planning, situation assessment, and communication and coordination. The primary advantages of virtual simulation, relative to live simulation, are the variety of training environments and locations that it can represent, and the reduced time that is required to prepare for and conduct exercises.

Utilization of Findings:

The results of this effort will be used to guide the development and application of future dismounted Soldier simulation capabilities, such as the Integrated MOUT Training System, the Virtual Emergency Response Training System, and the Soldier Combined Arms Tactical Trainer.

AN ASSESSMENT OF THE VIRTUAL–INTEGRATED MOUT TRAINING SYSTEM (V-IMTS)

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AN ASSESSMENT OF THE VIRTUAL–INTEGRATED MOUT TRAINING SYSTEM (V-IMTS)

Introduction

This report describes an assessment of the Virtual Integrated Military Operations in Urban Terrain (MOUT) Training System (V-IMTS). V-IMTS is a special project funded by the Defense Acquisition Challenge Program (DACP) to speed the transition of virtual training for Infantry Soldiers from the laboratory to the field. The report begins with a discussion of the Army's need for a dismounted Soldier virtual training capability. It is followed by a description of the relevant previous research and development which established the viability of virtual technology as a training option in the near term. V-IMTS goals and objectives are presented, and the technology selected for inclusion in the V-IMTS program described. The objectives of the V-IMTS assessment and the procedures that were used to meet those objectives are described in detail. Finally, the results and the recommendations for improvement and future use are described.

Background

The U.S. Army requires dismounted Soldier simulation capabilities to meet multiple needs. The first need is for simulations that allow dismounted leaders, Soldiers, and units to train effectively even if they do not have frequent opportunity to participate in high fidelity field training exercises. Second, leaders, Soldiers, and units need effective mission rehearsal tools that prepare them for specific combat missions in all types of terrain. Third, U.S. Army decision makers need inexpensive and high fidelity prototyping and testing systems that will allow them to explore and evaluate potential doctrine, organization, equipment, and Soldier characteristics. Opportunities to conduct "live" training exercises are decreasing due to cost, time, environmental, and safety constraints. The U.S. Army and the Department of Defense (DOD) have accepted the concept of using a mix of live, virtual, and constructive simulations to overcome these constraints. The Army has made a commitment to virtual training in the aviation, armor, and mechanized Infantry communities through the use of the Aviation Combined Arms Tactical Trainer and the Close Combat Tactical Trainer, but there is currently no comparable system in place to provide virtual training to dismounted Infantry or emergency responders. These needs are very important today. They are likely to become more important as the Army transformation continues.

Virtual Environment (VE) technologies have the potential to provide training, mission rehearsal, and experimentation capabilities for dismounted Soldiers and leaders. However, there has been no managed program to integrate and package available virtual training technologies for transition to the field. The V-IMTS program was designed to help satisfy these needs, although the technology is still in the late stages of research and development. Further development and testing is required to mature the technology before inserting it into an acquisition program.

Both the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) and the U.S. Army Research, Development, and Engineering Command, Simulation and Training Technology Center (RDECOM STTC) have had a long history of research and development programs related to the use of VE for dismounted Soldier simulation. Gorman (1990) was an early proponent of the use of virtual simulation for dismounted Infantry (DI) training. Partly as a result of his efforts, a conference was held in Snowbird, Utah in 1990 to discuss individual Soldier systems and the role that an individual portal (or I-Port) would play in their development (Goldberg and Knerr, 1997). Although consensus was achieved on the need for an I-Port, Operation Desert Storm preempted the initiation of a cooperative effort. The conference did provide the impetus for individual research programs, however.

The ARI effort began with an initial examination of the feasibility of using VE technology for dismounted Soldier training and the identification of difficult technical problems and research issues (Levison and Pew, 1993). This was followed shortly with a more detailed examination of DI unit tasks and expected VE capabilities (Jacobs et al., 1994). With these reports as a basis, ARI initiated an in-house research program to investigate critical behavioral science research issues involved in dismounted Soldier simulation. These ranged from the investigation of interface effects on task performance to the effects of geographically distributed team members on training effectiveness. Reviews of the research are contained in Knerr, Lampton, Singer, Witmer, and Goldberg (1998) and Lampton, Knerr, Martin, and Washburn (2002).

Dismounted Warrior Network (DWN) was a U.S. Army Simulation, Training, and Instrumentation Command (STRICOM)[1] program to develop a reliable, low-cost, easy-to-use capability to insert dismounted Soldiers into virtual simulations. A series of experiments was conducted during 1997 to investigate different simulator interfaces. Various simulators, a DI Semi-automated Forces (SAF) station, an Exercise Support Station, and an After Action Review (AAR) Station were tied into a distributed interactive simulation (DIS) network and installed at the Virtual Simulation Lab[2], Fort Benning, Georgia. An initial set of experiments showed that the DWN could be used to assess the utility of the emerging "immersive" simulation technologies (Lockheed Martin Corporation, 1997), both from a part-task engineering perspective and from a mission-oriented user perspective. ARI participated in the design and conduct of the experiments. (See Pleban, Dyer, Salter, and Brown, 1998.)

A follow-on project entitled DWN Enhancements for Restricted Terrain (DWN ERT) focused on MOUT. New low-cost simulators were modified based on lessons learned in the DWN experiments. New locomotion methods were introduced, improved low-cost visual systems were incorporated, and new aiming techniques were implemented. In addition, Dismounted Infantry Semi-automated Forces (DISAF) software was modified to support operations inside buildings. Experiments were conducted in July 1998 with these modified systems. The goal of this round of experiments was to investigate how well a fire team of Soldiers in simulators and DISAF could support MOUT tasks at the individual Soldier, fire team,

[1] As a result of a re-organization on 1 October 2002, the participating element within STRICOM became a part of the Research, Development, and Engineering Command, Simulation and Training Technology Center.
[2] Now named the Soldier Battle Lab.

squad, and platoon levels. The results are documented in the DWN ERT Final Report (Lockheed Martin Corporation, 1998) and Salter, Eakin, and Knerr (1999).

During the next phase of the research, the ARI Simulator Systems Research Unit (ARI-SSRU) and Infantry Forces Research Unit (ARI-IFRU), STRICOM, and the U.S. Army Research Laboratory Human Research and Engineering Directorate (ARL-HRED) and Computational and Information Sciences Directorate (ARL-CISD) participated in a joint Science and Technology Objective (STO) entitled “Virtual Environments for Dismounted Soldier Simulation, Training and Mission Rehearsal.” This four-year effort (FY99-FY02) focused on overcoming critical technological challenges to high fidelity dismounted Soldier simulation. These critical challenges included: simulating locomotion; tracking weapons and body positions; creating realistic performance of computer-controlled dismounted friendly and enemy Soldiers; simulation of night equipment and sensor images; making terrain and structures dynamic; developing appropriate training strategies and methods; assessing individual and unit performance; and determining transfer of training from virtual to live environments. The overall effort was successful, although some of the individual technologies were identified as requiring further improvement or not yet sufficiently mature for use. This STO contributed directly to many of the technologies used in V-IMTS, including the Dismounted Infantry Virtual After Action Review System (DIVAARS), the Soldier Visualization Station (SVS), and DISAF. One of the recommendations resulting from the effort was the following:

> Given the current state of technology, it appears that VE could be used effectively for some types of training and some stages of training. VE could be used for the walk phase of the training, concentrating on improving the decision making, situation awareness, communication, and coordination skills, while real world training could place greater emphasis on the motor skills. Therefore, although there are still further improvements that can be made in the individual technologies, as identified earlier in this report, the next step should be an advanced development effort, taking a total systems approach, to produce a prototype VE training system for the leaders of small dismounted Infantry units. (Knerr, 2003, pp. 47-48).

Objectives of V-IMTS

In November 2003, PM, GCTT received funding from the DACP for V-IMTS, a short-term project to speed the transition of the virtual simulation technology for dismounted Soldiers from the research and development community to the training environment. The program was expected to provide a virtual training system that would lay the foundation for rapid technology insertion into the three major acquisition programs: the Integrated MOUT Training System (I-MTS), the Virtual Emergency Response Training System (VERTS), and the Soldier Combined Arms Tactical Trainer (Soldier CATT). This dual-use technology could be used to immerse a warfighter or an emergency responder into a networked simulation, providing a training capability for homeland security, urban operations, and Weapons of Mass Destruction detection. This planned transition effort was to include an evaluation of the training technology as used by

Soldiers in a realistic training situation. RDECOM STTC provided the technical lead for the program, while ARI supported the planning and conduct of the assessment.

V-IMTS Description and the Technologies Involved

Physical Configuration

The Cassidy Combined Arms Collective Training Center at Fort Campbell, KY was selected as the initial transition site for V-IMTS and the site for the assessment. The Cassidy Center consists of a 28-building complex of one- to four-story buildings representing a small town. An aerial photograph is shown in Figure 1. A control building is adjacent to but physically separated from the complex. A digital control center and AAR facility is currently being installed in that building as part of the I-MTS program. At the time of the assessment in September 2004, the building was physically complete, including an AAR theater, but not all of the cabling and electronics which will eventually provide fully digital recording, editing, and playback of the video and audio from live exercises had been installed.

Figure 1. Aerial view of the Cassidy Combined Arms Collective Training Center. The control building is just out of the upper right side of the picture.

As part of the V-IMTS program, a deployable shelter approximately 40 feet square was placed next to the Cassidy control center. Three immersive Soldier Visualization Station immersive virtual individual Soldier simulators (SVSI) and six SVS desktop individual Soldier simulators (SVSD) were installed inside it. The physical layout of the shelter is shown in Figure 2. Cabling connected the simulators in the shelter with each other and with the main control room of the Cassidy control center.

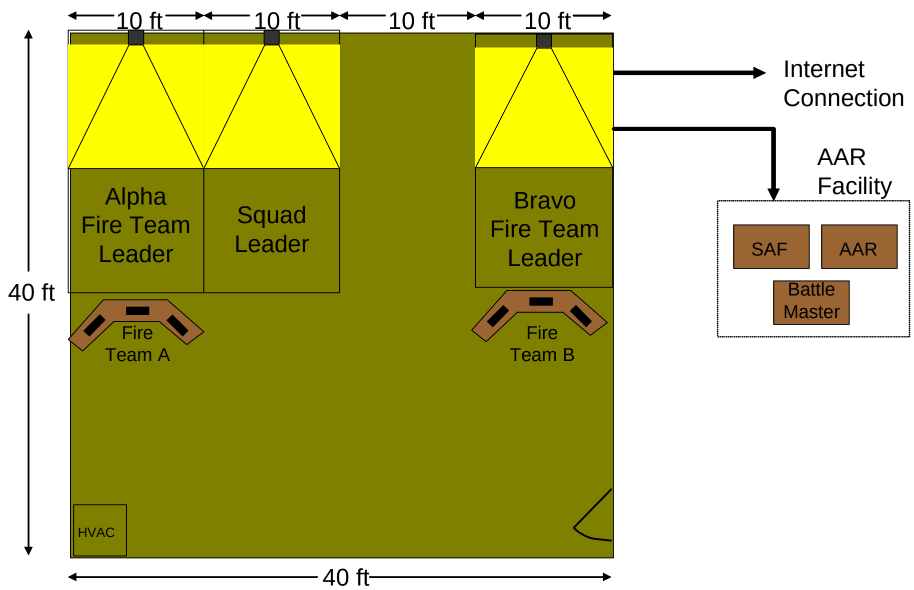

Figure 2. Diagram of the shelter layout.

Six computers were installed in the main control room to support the conduct of virtual scenarios: two for operation of the computer generated forces, one to provide stealth viewing for the Platoon Leader/Exercise Controller, one for AAR recording, and two for use by human Opposing Forces (OPFOR). An additional AAR computer was installed in an adjacent room for AAR playback.

Major Simulation Components

The SVSs are produced by the Reality Response Division of Advanced Interactive Systems, Inc. The two versions, SVSI and SVSD, are functionally similar but have different displays and controls. The SVSI is an immersive 3D virtual simulator. It is shown in Figure 3. The SVSI uses a rear-screen projection system to present images (800 X 600 resolution) on a screen approximately 10 feet wide by 7.5 feet high. The Soldier's head and weapon are tracked using an acoustic tracking system. The Soldier navigates through the environment via a thumb switch located on the weapon. The SVSD is functionally similar to the SVSI. The Soldier sits at a PC and views the simulation on an LCD monitor. A joystick is used to control view, movement and weapons use. The SVSI and SVSD have been in use and undergoing frequent updates at the Soldier Battle Lab, Fort Benning, for approximately six years.

Figure 3. A Soldier in an SVSI.

Dismounted Infantry Semi-Automated Forces (DISAF) was developed by SAIC to provide a realistic representation of dismounted Infantry and civilians on the virtual battlefield. The primary focus of DISAF has been the representation of tactical behaviors for individual through squad level operations. DISAF is based on the Modular SAF/ OneSAF TestBed architecture. DISAF includes support for urban and rural terrain operations. Most of the DISAF behaviors are based on validated military Combat Instruction Sets. DISAF provides an enhanced 2D Plan View Display to support display of Multiple Elevation Structure buildings and individual entity icons, and can be networked to a stealth viewer to provide a 3D display. DISAF runs on a PC under Linux or Windows NT. DISAF Version 9.4 was used to provide virtual OPFOR, civilians, and other friendly squads for the exercises. DISAF is functionally equivalent to OneSAF Testbed SAF (OTBSAF). DISAF capabilities are summarized in Table 1.

Table 1
DISAF Capabilities and Behaviors

DISAF/CGF – Capabilities Entities and Units • US IC w/ M16A2, C4 Charges, and Fragmentation, Smoke and Stun Grenades • US IC w/ AT8, C4 Charges, and Fragmentation, Smoke and Stun Grenades • US IC w/ Squad Automatic Weapon (SAW), C4 Charges, and Fragmentation, Smoke and Stun Grenades • US IC w/ M203, C4 Charges, and Fragmentation, Smoke and Stun Grenades • US IC Fireteam A (M16, AT8, M203, SAW) • US IC Fire team B (M16, M16, M203, SAW) • US IC Fire team C (M16 x 3, SAW) • US IC Auto Weapons Team (M16 x 2, SAW) • US IC Squad (M16, Fire team A, Fire team B) • US IC Rifle Squad (M16, Fire team B x 2) • US IC Auto Weapons Squad (M16, Auto Weapons Team x 3) • US IC Platoon (M16 x 2, Rifle Squad x 3, Auto Weapons Squad) • USSR IC AK47 • USSR IC Squad (AK47 x 6) • US IC Combat Medic • IC Armed Civilian w/ 9mm handgun • Crowd Units ▪ 5 Men In Suit ▪ 5 Men In Jacket ▪ 5 Women In Suit ▪ 5 Women In Skirt ▪ 5 IC Armed Civilian ▪ 4 Mixed Civilian ▪ 10 Mixed Civilian ▪ 20 Mixed Civilian • Civilians ▪ Man In Suit ▪ Man In Jacket ▪ Woman In Suit ▪ Woman In Skirt ▪ IC Physician ▪ IC Physician Assistant • Furniture • Structures ▪ Battalion Aid Station Structure ▪ Forward Surgical Team Structure ▪ Combat Support Hospital Structure • UH60Q Blackhawk Helicopter Ambulance • Bus Ambulance	**BLUFOR Behaviors** • Halt • Fire & Movement • Throw Grenade • Place Charge • Occupy Position • Fire at Location • React to Ambush • Suppressive Fire • React to Contact • Move on Path • Break Contact • Mount / Dismount Ground / Air Unit • Clear Room • Move Tactically • Climb Up / Down • Move Injured IC • Hold Hostage • Withdraw • Shoot Human • Station Keeping • IC Joystick Control **Automated Urban Behaviors** • Fire Team Clear Room • Squad Clear Room **Autonomous OPFOR Behaviors** • Look Around • Face Bogey • Engage Threat • Seek Cover • Watch • Engage from Cover • Fall Prone & Freeze • Freeze • Pursue Threat **Autonomous Civilian Behaviors** • React to Fire • Wander
Plan View Display (PVD) • Greater Zoom-In Capability (1:25 Map Scale) • View Multiple Elevation Structures (MES) interiors, one level at a time • MES windows, doors, and openings are distinguished by color • Can display entity altitude to indicate MES level • IC icons indicate posture and weapon position	**Crowd Idle Behaviors** • Do Nothing • Move Toward Crowd Center • Move To Nearby Civilian • Wander In Random Direction

The Dismounted Infantry Virtual After Action Review System (DIVAARS) is a PC-based AAR system developed by ARI and the University of Central Florida Institute for Simulation and Training (IST) specifically to meet the AAR requirements for dismounted Infantry in urban combat. The key capabilities of DIVAARS are digital videodisc (DVD)-like replay with synchronized audio and video, including the capability to jump to pre-designated segments or views, and tabular data summaries. It also includes a "Windows-like" interface, addition of the capability to view building interiors, and voice communication capture and replay. The DIVAARS is described in detail in Knerr, Lampton, Martin, Washburn, and Cope, (2002). A DIVAARS display is shown in Figure 4.

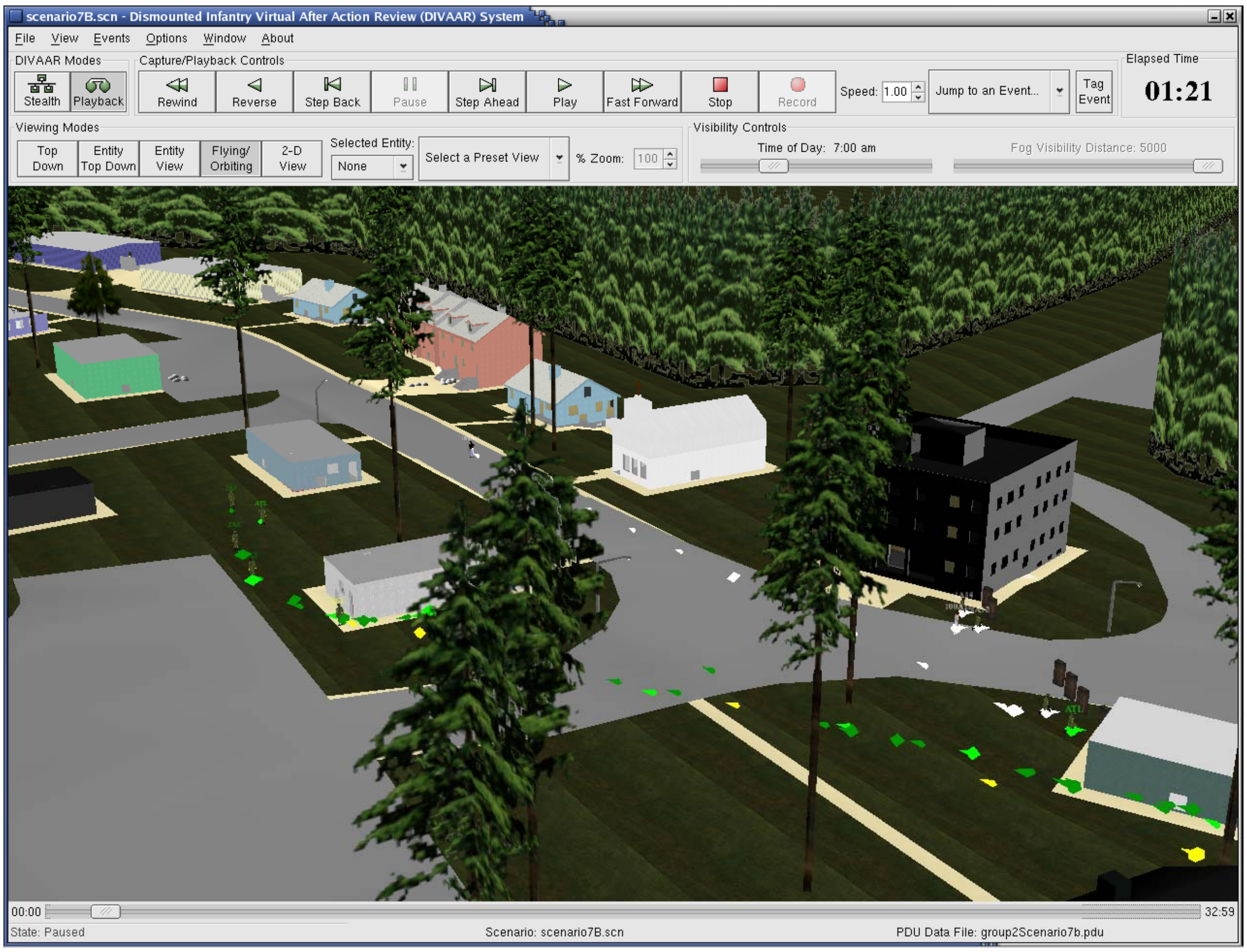

Figure 4. A Sample DIVAARS Display.

Networking and Connections

The network configuration for the assessment is shown in Figure 5. The following items were connected to the network:

- Three SVSI simulators used by the squad leader and the two fire team leaders. These were located in the shelter.

- Six SVSD simulators used by the Soldiers in the Alpha and Bravo fire teams. These were also located in the shelter.
- Two DIVAARS systems. One was used for exercise recording and was located in the Control Room. The second was located in a room adjacent to the AAR theater and was used for playback.
- One BattleMaster Station, consisting of an SVSD stealth viewer and two DISAF computers. The Platoon Leader/Exercise Controller and the DISAF Operator used this station, which was located in the Control Room.
- Two SVSDs used by Soldiers role-playing OPFOR. These were located in the Control Room.

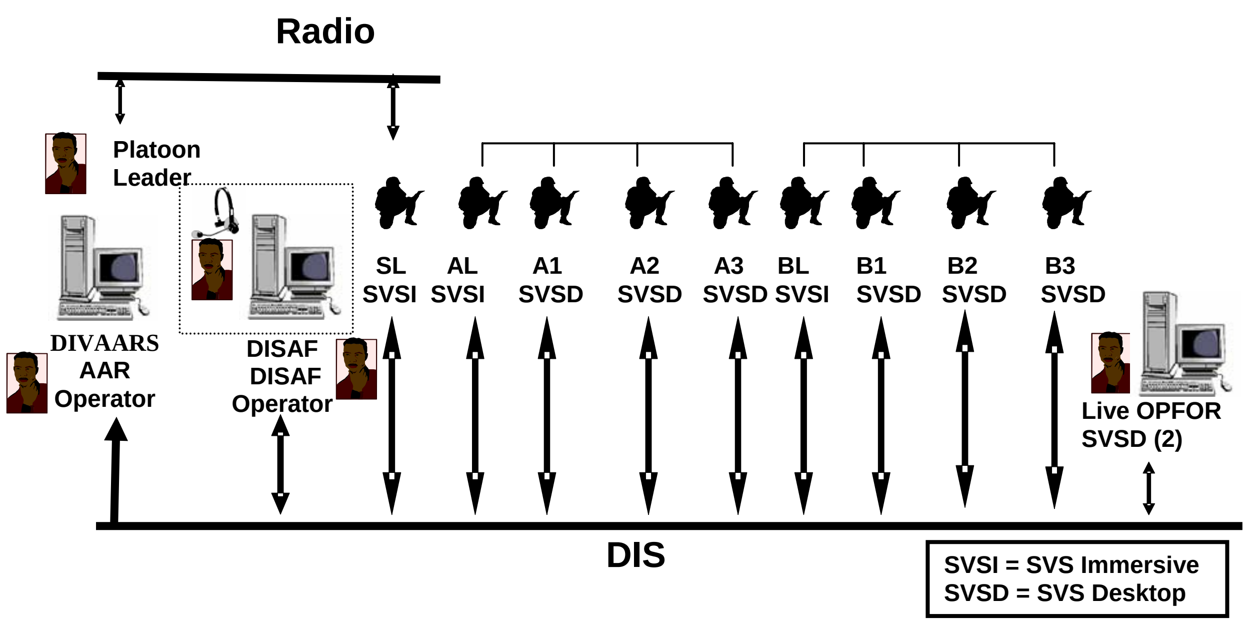

Figure 5. Network configuration

Assessment Activities

Overall Schedule

The assessment took place during a two-week period in September 2004. Severe weather in Florida prior to and during that period (Hurricanes Ivan and Jeanne) resulted in travel and related delays that necessitated last-minute schedule changes. Because the end date for the assessment was fixed by operational requirements, the net impact was to compress some portions of the schedule.

The first 1 ½ days were used for set-up, integration, and scenario testing. The Platoon Leader and Platoon Sergeant received an introduction to the project and their roles in it on the afternoon of Day 2. On Day 3, the three participating squads received an introductory briefing on the purpose of the assessment and their roles, completed background information questionnaires, and were given their initial train-up and practice on the use of the simulators. Concurrently, the

Platoon Leader and Platoon Sergeant received training on the live and virtual AAR systems that they would use, and also began review of the scenarios that would be used during the assessment. Day 3 concluded with an unstructured group feedback session during which the Soldiers, all of whom had received training and some practice using the simulators, provided feedback and suggestions for improvement. On Days 4 and 5 the first squad completed its training cycle as planned: one live scenario in the actual MOUT site, followed by six scenarios in the virtual simulators (three on Day 4 and three on Day 5), and finally a second live exercise on the afternoon of Day 5. Each exercise, whether live or virtual, consisted of a sequence of receipt of the mission order by the Squad Leader, mission planning, mission execution, and AAR. The Platoon Leader, assisted by the Platoon Sergeant and technical personnel, delivered the orders, served as the exercise controller, and conducted the AAR.

Days 6 and 7 were a weekend with no activities scheduled. The schedule disruption began on Day 8 when Hurricane Jeanne disrupted air travel. Technical personnel were not available to support the conduct of the virtual exercises, so Squad 2 conducted only one live exercise. On Day 9, Squad 2 completed two virtual exercises and one live exercise. Squad 2 returned for a third day, Day 10, when they completed two virtual exercises, one in conjunction with the initial live exercise involving Squad 3. Squad 3 conducted their initial live exercise on Day 10, followed by one virtual exercise that day and two virtual and one live exercise on Day 11. To summarize, each squad completed two live exercises separated by two, three, or six virtual exercises. (See also Table 2.) In addition, since Squad 2 completed two virtual exercises after their second live exercise, each squad completed at least three virtual exercises. Squad 1 participated in six virtual exercises lasting a total of approximately 96 minutes (mean = 16 minutes), squad 2 participated in four virtual exercises lasting a total of 77 minutes (mean = 19.25 minutes), and squad 3 participated in three virtual exercises lasting a total of 44 minutes (mean = 14.67 minutes). Overall mean duration of the virtual exercises was 16.69 minutes.

Table 2
Sequence of Events

Date	23 Sep	24 Sep	27 Sep	28 Sep	29 Sep	29 Sep	30 Sep
Day	4	5	8	9	10	10	11
Squad	1	1	2	2	2	3	3
Exercise 1	Live	Virtual	Live	Virtual	Virtual	Live	Virtual
Exercise 2	Virtual	Virtual		Virtual	Virtual	Virtual	Virtual
Exercise 3	Virtual	Virtual		Live			Live
Exercise 4	Virtual	Live					
Other		Question-naires & Interviews			Question-naires & Interviews		Question-naires & Interviews

Scenarios

RDECOM STTC developed Training Support Packages (TSPs) consisting of Dismounted Infantry Scenarios based on ARTEP 7-8, with OPFOR tactical elements taken from ARTEP 7-5. In cooperation with the Infantry School, U.S. Army Training and Doctrine Command (TRADOC) Program Integration Office (TPIO) Virtual, and the 101st Airborne Division, two missions were developed: Search and Cordon a Building and Attack/Assault a Building. Multiple scenarios were developed for each mission which differed in the buildings involved and the positions and actions of the OPFOR.

After Action Reviews

All AARs, both live and virtual, took place in the same room and were usually led by the same Platoon Leader, although each Squad Leader conducted one AAR with his squad. The overall structure of each AAR was:

- Review of the mission order
- Review of the enemy situation
- Review of key events
- Identification of "Sustains" and "Improves"

The live exercises were recorded by video cameras external to the buildings and cameras and microphones inside the buildings. The camera viewpoints were fixed and not all-inclusive. The AAR Leader used video segments to illustrate the key events. The permanent video recording and editing capabilities had not been installed at the time the assessment was conducted. To provide a reasonable approximation of the capabilities expected to be available when the installation was completed, a temporary capability was installed on Days 6 and 7, and was used for Days 8–11.

The virtual exercises were recorded by the DIVAARS, which recorded the data transmitted over the simulator network. DIVAARS playback was not limited to preset positions: a segment could be replayed from any viewpoint, or at any speed. However, since voice communications were not transmitted over the network, it did not capture voice communications.

Questionnaire descriptions

Biographical Information Questionnaire. The Biographical Information Questionnaire was administered to all of the Soldiers in the three squads on the morning of Day 3. It consisted of 17 items asking about age, MOS, duty position, prior military training and experience, physical characteristics (visual acuity and color vision, handedness), computer and video game usage, and similar items.

Soldier Questionnaire. The Soldier Questionnaire was administered to all of the Soldiers in the three squads after they had completed all of their training (both virtual and live). It had three parts. Part I, Simulator Capability, consisted of 54 items describing individual Soldier combat activities. Soldiers rated their ability to perform each of those tasks in the virtual simulator as *Very Poor, Poor, Good, Very Good, or Did Not Perform*. Part II, After Action

Review, consisted of eight statements about the AAR conducted after each exercise. Soldiers indicated their extent of agreement with each statement as *Strongly Agree, Agree, Neither Agree nor Disagree, Disagree, or Strongly Disagree*. They did this first for the live AARs, and then rated the same items for the virtual AARs. Part III, Training Effectiveness, consisted of a list of 11 tasks. Soldiers rated their improvement on each of the tasks as *No Improvement, Slight Improvement, Moderate Improvement, or Vast Improvement.*

Symptom Checklist. The *Symptom Checklist* is a list of symptoms used to assess simulator sickness. It is a modified version of a checklist developed by Kennedy, Lane, Berbaum, & Lilienthal (1993). Each of 16 symptoms is rated as *None, Slight, Moderate*, or *Severe*. It was administered to all Soldiers prior to their first use of the virtual simulators each day and after each use of the virtual simulators.

Structured Interview. In addition to the questionnaires, a structured interview was used to obtain more in-depth information and feedback from the Soldiers. After the Solders had completed all of the exercises and the Soldier Questionnaire, they were split into two groups Leaders (N=3 per group) and Soldiers (N=6) and asked a series of questions. Leaders and Soldiers were separated because they used different simulators (leaders used the immersive simulators and Soldiers used the desktops), and we did not want the differences in rank to interfere with the free flow of opinions.

All questionnaires and the structured interview are included in Appendix B.

Other Data Collection Opportunities

As the events of the assessment unfolded, we were able to take advantage of several other opportunities to obtain feedback from the Soldiers. First, following their initial train-up on Day 3, the Soldiers provided suggestions for improvement in a largely unstructured group format. About 20 suggestions were provided. Second, as part of their AAR process, the Soldiers provided simulator “Sustains” and “Improves” after each virtual exercise. At the end of the assessment, a consolidated list of sustains and improves was prepared and reviewed by the Platoon Leader and Platoon Sergeant. The result was a loose prioritization of the items on the list.

Results

The Soldiers

Twenty-seven Soldiers from three squads participated. The squads were actual units, not groups formed specifically for this event. All Soldiers were male and in MOS 11B. Mean age was 22.2 years. They had a mean time in service of 30.6 months and time in their current duty position of 5.9 months. Sixty-eight percent had served a tour in Iraq or Afghanistan. None of the squad leaders, and only three of the six team leaders, had served in their current duty position for more than one month. Ninety-three percent reported 20/20 vision, 96% normal color vision, and 89% were right-handed. They reported a mean of 11.5 hours of computer use per week (median 3.5 hours) and a mean of 9.5 hours (median 6.5 hours) per week playing computer or video games. (These numbers are not additive. Time spent playing games on a PC would be included in the response to both questions.) They described their confidence using computers as slightly above average (mean 3.3 on a 5-point scale).

Simulator Capability

The results for Part I of the Simulator Questionnaire are shown in Table 3. The activities are presented in descending order of the combined mean rating (SVSI and SVSD). Overall, the Soldiers rated their ability to perform 15 of the 54 combat activities as Good or better (mean ≥ 2.00). Highly rated activities include outdoor movement, identification of types of people (civilians, non-combatants within a room, enemy Soldiers), identification of tactically significant areas (sectors of observation and responsibility), and individual weapons use (but not grenades). Poorly rated items included maneuver indoors (close to others, past furniture, close to walls, around objects, past other personnel, around corners, through doorways, up and down stairs), and making decisions about the source and type of fire (enemy or friendly), either by auditory or visual cues.

Ratings by the leaders using the SVSI and the Soldiers using the SVSD were similar but not identical. The SVSD was rated slightly but not significantly higher than the SVSI (mean rating of 1.76 vs. 1.66). The SVSI and SVSD ratings were positively correlated ($r = .62$), indicating that the same activities tended to be rated similarly on both simulators. However, there were exceptions. Aiming and firing the weapon accurately, and using smoke, fragmentation, and flash-bang grenades were rated higher in the SVSI than in the SVSD, while the opposite was true for identifying and locating enemy Soldiers, and identifying assigned areas of observation ($p<.05$).

The three squads differed slightly in their overall ratings, with the mean for Squad 1 (1.82) slightly higher than the means for Squad 2 and Squad 3 (1.65 and 1.69, respectively).

Table 3
Simulator Capability Questionnaire Results

Combat Activity	Overall			SVSI			SVSD		
	Mean	Rank	N	Mean	Rank	N	Mean	Rank	N
Move through open areas as a widely separated group.	2.50	1.5	27	2.67	1.5	9	2.41	2.5	18
Identify civilians.	2.50	1.5	27	2.56	3.5	9	2.47	1	18
Identify non-combatants within a room.	2.46	3	27	2.56	3.5	9	2.41	2.5	18
Execute planned route.	2.38	4	27	2.44	6.5	9	2.35	4.5	18
Fire weapon in short bursts.	2.29	5	26	2.50	5	8	2.19	8.5	17
Move in single file.	2.27	6	27	2.11	1.5	9	2.35	4.5	18
Locate assigned areas of observation, e.g. across the street.	2.24	7	26	2.33	8.5	9	2.19	8.5	17
Execute the assault as planned.	2.23	8	27	2.33	8.5	9	2.18	11	18
Fire weapon accurately.**	2.12	9	27	2.67	1.5	9	1.82	24	18
Identify assigned sectors of observation.**	2.09	10	24	1.78	22	9	2.29	6	15
Identify sector of responsibility.	2.08	11.5	26	1.88	19	8	2.18	11	18
Engage targets within a room.	2.08	11.5	27	1.89	17	9	2.18	11	18
Move according to directions.	2.04	14	27	2.11	10.5	9	2.00	16	18
Move quickly to the point of attack.	2.04	14	27	1.89	17	9	2.12	13.5	18
Identify enemy Soldiers.**	2.04	14	27	1.67	27	9	2.24	7	18
Maintain position relative to other team/ squad members.*	1.96	16	27	1.67	27	9	2.12	13.5	18
Locate fire team buddy positions.	1.92	17	25	1.78	22	9	2.00	16	16
Aim weapon.***	1.88	19	26	2.44	6.5	9	1.56	34.5	17
Understand verbal commands.	1.88	19	26	1.67	27	9	2.00	16	17
Coordinate with other squad members.	1.88	19	25	1.89	17	9	1.87	23	16
Identify safe and danger areas.	1.87	21	24	1.78	22	9	1.93	20.5	15
Scan from side-to-side.	1.85	22	27	1.67	27	9	1.94	18.5	18
Identify covered and concealed routes.	1.81	23.5	24	2.00	13.5	7	1.71	29	15
Take a tactical position while within a room.	1.81	23.5	27	1.56	32	9	1.94	18.5	18
Locate support team positions.	1.78	25	24	1.56	32	9	1.93	20..5	15
Communicate SPOT reports to squad leader.	1.76	26	23	1.50	34.5	8	1.92	22	14
Assume defensive positions.	1.73	27	23	1.75	23	8	1.71	29	15
Scan the room quickly for hostile combatants.	1.69	28	27	1.56	32	9	1.76	25	18
Communicate enemy location to team member.	1.66	29	26	1.50	34.5	9	1.75	26.5	17
Maneuver below windows.	1.60	30.5	15	1.86	20	7	1.38	39	8
Determine other team/ squad members' positions.	1.60	30.5	26	1.67	27	9	1.56	34.5	17
Locate enemy Soldiers inside buildings firing at your unit.	1.58	32	25	1.25	40	8	1.75	26.5	17
Employ tactical hand-held smoke grenades.	1.57	33	7	2.00	13.5	4	1.00	51	3
Use flash-bang grenades to help clear rooms.	1.55	34	11	2.00	13.5	5	1.17	45	6

Combat Activity	Overall			SVSI			SVSD		
	Mean	Rank	N	Mean	Rank	N	Mean	Rank	N
Take position to one side of the doorway.	1.54	35	27	1.22	42.5	9	1.71	29	18
Take hasty defensive positions.	1.53	36	20	1.67	27	9	1.40	38	11
Identify areas that mask supporting fires.	1.50	37	19	1.38	37	8	1.60	32	12
Maneuver close to others.	1.46	38.5	27	1.33	38.5	9	1.53	36.5	18
Visually locate the source of enemy fire.	1.46	38.5	27	1.22	42.5	9	1.59	33	18
Move past furniture in a room.	1.44	40	9	1.67	27	3	1.33	40	6
Move close to walls.	1.42	41	27	1.22	42.5	9	1.53	36.5	18
Scan vertically.	1.35	42	27	0.78	52	9	1.65	31	18
Maneuver around obstacles.	1.32	43	26	1.33	38.5	9	1.31	41	17
Use hand-held illumination (flares).	1.20	44	5	2.00	13.5	2	0.67	54	3
Estimate distances from self to a distant object.	1.16	45	26	1.00	46	9	1.25	43	17
Look around corners.	1.15	46	27	1.22	42.5	9	1.12	47.5	18
Distinguish between friendly and enemy fire.	1.15	47	27	0.89	49.5	9	1.29	42	18
Maneuver past other personnel in a room.	1.12	48	27	0.89	49.5	9	1.24	44	18
Determine the source of enemy fire by sound.	1.08	49	27	1.00	46	9	1.13	46	18
Use fragmentation grenades.	1.03	50	19	1.40	36	5	0.88	53	14
Maneuver around corners.	1.00	51.5	27	1.00	46	9	1.00	51	18
Move quickly through doorways.	1.00	51.5	27	0.78	52	9	1.12	47.5	18
Climb up or down stairs.	0.96	53	24	0.75	52	8	1.07	49	16
Determine the direction enemy rounds are coming from.	0.92	54	25	0.78	54	9	1.00	51	16
Mean	1.72			1.66			1.76		

* Difference between SVSI and SVSD approaches statistical significance (p<.10)
**Difference between SVSI and SVSD is statistically significant (p<.05)
***Difference between SVSI and SVSD is statistically significant (p<.01)

After Action Reviews

The ratings of the AAR systems are presented in Table 4. Overall, the Soldiers gave the AAR systems very good ratings, with the mean ratings for all of the positively worded items except one averaging 3.0 or greater on a scale where 3.0 was Agree and 4.0 was Strongly Agree. The lowest-rated items, for both the live and virtual AAR systems, had to do with communications. There was no way to record verbal communications in the virtual simulation. In the live simulation, verbal communications were recorded inside buildings, but not outdoors. The ratings for the virtual AARs were slightly lower than the ratings for the live AARs.

Table 4
AAR Questionnaire Results

Questionnaire Item	Live or Virtual AAR	Strongly Agree (4)	Agree (3)	Neither Agree nor Disagree (2)	Disagree (1)	Strongly Disagree (0)	Mean
1. The AAR system was effective in displaying movement outside of buildings.	Live	16	10				3.62
	Virtual	16	8	2			3.54
2. The AAR system was effective in displaying movement inside of buildings.	Live	11	15				3.42
	Virtual	12	12	2			3.38
3. The AAR system was effective in replaying communications.	Live	13	4	5	4		3.00
	Virtual	8	5	6	6	1	2.50
4. The AAR system made it easy to determine what happened during a mission.	Live	19	7				3.73
	Virtual	16	8	2			3.54
5. The AAR system made it easy to determine why things happened the way they did during a mission.	Live	18	4	3	1		3.50
	Virtual	12	9	4	1		3.23
6. The AAR system made it easy to determine how to do better in accomplishing the mission.	Live	18	7	1			3.65
	Virtual	14	10	2			3.46
7. The AAR system made it easy to determine the order in which key events occurred during the mission	Live	17	9				3.65
	Virtual	12	14				3.46
8. The AAR system was more effective than conducting an AAR without any visual or audio playback (just talking).	Live	17	3	5		1	3.35
	Virtual	18	6	2			3.62

Training Effectiveness

The training effectiveness ratings are presented in Table 5. The mean rating for training effectiveness was 1.79 on a scale where 1 equaled slight improvement and 2 equaled a moderate improvement. Interestingly, both the leaders and the Soldiers reported about the same amount of overall improvement, although the skills on which they reported improving the most differed. Leaders reported the greatest improvement on “Control of squad/fire team movement during the assault,” “Assess the tactical situation,” “Plan a tactical operation,” and “Coordinate activities with your chain of command.” Soldiers reported the most improvement on “Plan a tactical operation,” “Coordinate activities with your chain of command,” and “Communicate with members of your team or squad.” Perhaps because of the small numbers involved, the differences between leader and Soldier ratings approached significance for only one task, “Control of squad/fire team movement during the assault.”

Table 5
Training Effectiveness Questionnaire Results

Question	Leaders	Soldiers	Combined
N	9	18	27
Plan a tactical operation.	2.11	2.18	2.15
Coordinate activities with your chain of command.	2.00	2.00	2.00
Assess the tactical situation.	2.33	1.76	1.96
Control of squad/fire team movement during the assault. *	2.44	1.71	1.96
Communicate with members of your team or squad.	1.89	2.00	1.96
Clear a building.	1.33	1.94	1.73
Clear a room.	1.33	1.88	1.69
Control squad or fire team movement while not in contact with the enemy.	1.67	1.69	1.68
Control your squad or fire team.	1.67	1.59	1.62
React to Contact Battle Drill.	1.11	1.65	1.46
Locate known or suspected enemy positions.	1.22	1.59	1.46
Mean	1.74	1.82	1.79

Note: None = 0, Slight = 1, Moderate = 2, and Vast = 3.
* Difference between ratings of Soldiers and Leaders approached statistical significance ($p<.10$).

Simulator Sickness

The simulator sickness questionnaire was scored by assigning a scores of 0, 1, 2, and 3, to reported symptoms of None, Slight, Moderate, and Severe, respectively. An overall Total Severity Score and Scores on three subscales, Nausea, Oculomotor Discomfort, and Disorientation were also calculated. The symptom “warm sweating” was included on the questionnaire to distinguish warm and cold sweating, but was not included in any of the calculations. We first looked for overall changes in reported symptoms as a result of simulator use. The results are shown in Table 6.

Table 6
Changes in reported symptoms as a result of simulator use

	Pre	Post	Change (Post – Pre)
All Simulators			
N	54	54	54
Total Severity	1.78	2.32	0.55
Nausea	0.43	0.48	0.06
Oculomotor	0.85	1.30	0.44
Disorientation	0.50	0.55	0.05
SVSI			
N	18	18	18
Total Severity	2.50	3.50	1.00
Nausea	0.50	0.72	0.22
Oculomotor	1.00	1.67	0.67
Disorientation	1.00	1.11	0.11
SVSD			
N	36	36	36
Total Severity	1.42	1.74	0.32
Nausea	0.39	0.36	-0.03
Oculomotor	0.78	1.11	0.33
Disorientation	0.25	0.26	0.01

While there was an increase in the overall frequency and severity of symptoms following simulator use, the increase was slight, averaging about the equivalent of one-half (0.55) a unit increase in one symptom. The increase was larger for Solders in the SVSI (1.00) than for Soldiers using the SVSD (0.32). This difference, both overall (Total Severity) and for the Oculomotor and Disorientation subscales, approached statistical significance at $p<.10$.

Table 7
Changes in individual symptoms as a result of simulator use

Symptom	Pre	Post	Difference (Post – Pre)
Eyestrain	0.11	0.31	0.20*
Fatigue	0.17	0.24	0.07
Headache	0.11	0.20	0.09**
General discomfort	0.13	0.17	0.03
Blurred vision	0.08	0.15	0.07
Difficulty Focusing	0.15	0.13	-0.02
Stomach awareness	0.09	0.13	0.04
Difficulty concentrating	0.11	0.09	-0.02
Fullness of the head	0.11	0.09	-0.02
Nausea	0.06	0.07	0.02
Dizzy eyes closed	0.06	0.06	0.01
Dizzy eyes open	0.04	0.02	-0.02
Vertigo	0.02	0.02	0.00
Burping	0.02	0.02	0.00
Salivation Increased	0.00	0.00	0.00
Cold Sweating	0.02	0.00	-0.02

* Difference was statistically significant ($p<.05$)
**Difference was statistically significant ($p<.01$)

Looking at the individual symptoms (Table 7), the single symptom that showed the greatest increase as a result of simulator use was eyestrain. This was the case for both the SVSI and SVSD. Headache also showed a significant increase. Changes in other symptoms were negligible (≤.07) and not statistically significant.

Interview Results

The interviews served largely to confirm and amplify the information that was obtained from the questionnaires. Some key points are:

- The Soldiers perceived the mission rehearsal aspects of the virtual simulation to be a major benefit.
- Precise movement was the biggest problem with the simulators. It was hard to stack, pie corners, and move in confined areas.
- The potential variability in scenarios, and the relatively short amount of time required to prepare for and conduct scenarios, were seen as advantages of virtual simulation relative to live simulation.
- Both the live and virtual AARs were perceived very positively. The capability to show what actually happened improved the credibility of the feedback and, in some cases, showed Soldiers doing things that they were not aware of.
- Soldiers did not believe that they learned any bad habits in the simulators, but a few expressed a concern that new Soldiers might treat the simulators like a video game and do things in the simulators that they would not do in the real world.

Sustains and Improves

During the AARs, the Soldiers identified “simulator improves,” problems or areas for improvement. A total of 24 items were generated, although these were not all unique. At the conclusion of the evaluation, these were reviewed with the Platoon Leader and Platoon Sergeant to clarify the items and obtain information about their relative importance.

One item was changed “on the fly” as a result of Soldier feedback. Initially Soldier icons, both in the SVS and in DIVAARS, had been identified by a three-character alphanumeric that indicated their squad, team, and position in that team, e.g., 1A2 for 1st squad, Alpha fire team, second member, or 1BL for 1st squad, Bravo fire team leader. Soldiers asked for a three-letter code based on each Soldier’s last name, e.g., JON for Jones. This was implemented during the assessment.

The issue of fine or precision movement in confined areas emerged as the most important item from the list of improvements. This is consistent with information obtained from the questionnaires and interviews. It involves a number of related issues: the size of the bounding box which detects collisions between Soldiers and other objects, and between Soldiers; the limited texture and shading cues on the walls inside buildings; the relatively narrow field of view of the SVS displays (both SVSI and SVSD); the problem representing objects in the SVSI which are located between the Soldier and the rear-projection screen; and the linkage between direction of gaze and direction of movement. While both Soldiers and leaders presented a number of potential movement control solutions to this problem, it appears to be a more complicated problem than can be solved by building a new movement control device.

A minor point with regard to movement control was that Soldiers felt that any movement control on the weapon should be on the front stock, away from the trigger and safety. This means that most Soldiers would operate it with their non-preferred hand.

The next most important improvement involved communications. There are two aspects. First, Soldiers need to be able to communicate with each other and with their commander. This requires both radio (among Platoon Leader, Squad Leader, and Team Leaders) and face-to-face (among Team Leaders, Soldiers, civilians, etc.) communications. For radio communications, use of organic equipment is the preferred approach. Second, the communications need to be recorded and synchronized with other scenario events for use in the AAR. While V-IMTS included a commercial solution which would have satisfied all of the requirements except the use of organic equipment, the time lag in the delivery of the communications was so great that it could not be used. A combination of the use of organic equipment with microphones in the shelter might be a solution.

The third most important improvement involved non-voice sounds. Two categories of sounds can be defined: battlefield sounds and environmental sounds. The distinction depends to some extent on the context: weapons firing or explosions are always battlefield sounds; crickets chirping, a running stream, and the wind in the trees are always environmental sounds; and vehicle engines, footsteps, and a dog barking could be either, depending on whether on not they provided situational awareness cues. Battlefield sounds are required. Environmental sounds are not. In addition, directional cues are important for battlefield sounds, with limits. In an urban area, directional cues for distant sounds (outside the building you are in) are usually lost anyway.

The effects of wounding (limitation of movement and/or firing capabilities, with eventual "bleeding out" leading to death) were generally perceived as good. However, two improvements were requested. The first was the capability to do "buddy aid," e.g., a way for a team member to simulate first aid and stabilize the wounded Soldier's condition. The second was the incorporation of body armor, not necessarily visually, but its inclusion in the calculation of the weapons effects.

Other capabilities requested were the capability to mark a room by dropping a highly visible object, a means to control civilians, and a way to give limited hand and arm signals.

An interface issue which affected the performance of many combat activities was the need for a re-structured menu system for the SVS. There was no way to cycle backwards through the choices if you overshot the one you were seeking. This led to delays in taking actions such as throwing grenades.

Discussion

The results of the assessment can and should be viewed from two perspectives. First, how does V-IMTS perform as a means for training now? Second, what was learned about requirements for next-generation systems?

The Soldier simulator configuration (three SVSIs for the squad and fire team leaders and six SVSDs for the remainder of the squad) proved to be successful. However, other options can and should be explored. These would include the use of all SVSD (which would have considerable savings in acquisition cost and space requirements) and the use of wearable simulators with Head-Mounted Displays.

The different V-IMTS components (SVS, DISAF, DIVAARS) were well integrated. This was to be expected based on previous efforts.

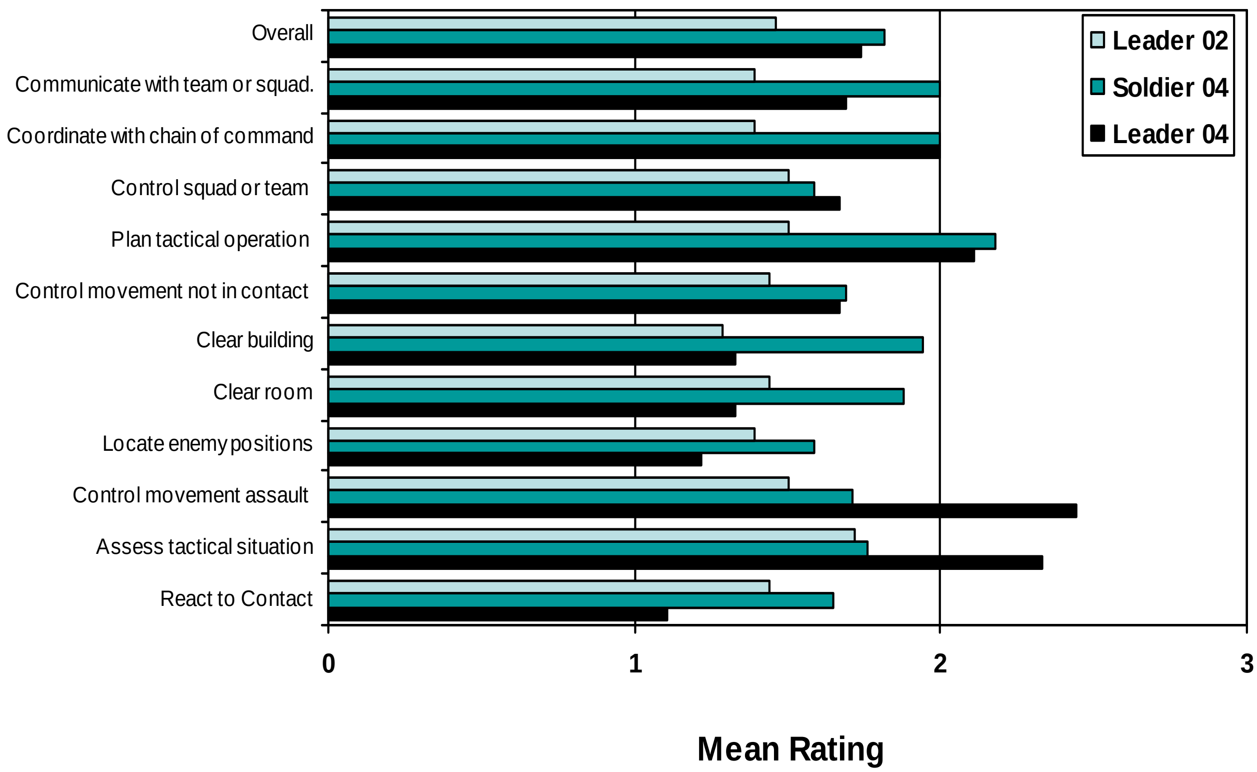

Figure 6. A comparison of ratings of skill improvement.

It was clear from the questionnaires, interviews, and informal comments made during the assessment that the Soldiers and their Platoon leadership believed that they were receiving effective training. Leader and Soldier ratings of their skill improvement compared favorably with the ratings made by a group of squad and fire team leaders who participated in virtual exercises at the Soldier Battle Lab in 2002 (Knerr et al, 2003). V-IMTS leader ratings ($M = 1.74$) and Soldier ratings ($M = 1.82$) were higher than the 2002 ratings ($M = 1.44$), although this difference was not statistically significant, $F(2, 41) = 1.37$, $p = .265$). Figure 6 provides a comparison of the three groups on each of the eleven skills measured.

These effectiveness data should be viewed with caution for several reasons. First, there is no objective data that the skills of the Soldiers actually improved, only their self report that it did, collaborated by the impressions of their Leaders. In addition, we do not have good anchors for what a mean skill improvement rating of 1.79 actually means, or how much improvement comparison squads who received other forms of training, such as all live exercises or desktop simulations might have reported. Ideally, we would like to have more objective measures. Finally, these training effectiveness data reflect the combined effects of the live and virtual exercises. We believe that this is appropriate because V-IMTS involves the integrated use of live and virtual simulation.

The Soldiers' ratings of their ability to perform tasks in the simulator were lower than expected based on the results of data we obtained in exercises conducted at Fort Benning in 2002 and the Summer of 2004. The overall simulator capability rating for the three assessments are presented in Figure 7. When those groups who used the SVS immersive simulators are compared, the ratings of the V-IMTS leaders (V-IMTS SVSI in Figure 7, $N = 9$, $M = 1.66$) were significantly lower than those of a combined group of Soldiers and leaders in 2002 (2002 SVSI, $N = 18$, $M = 2.13$) and Soldiers in 2004 (2004 SVSI, $N = 12$, $M = 2.10$) A one-way ANOVA showed this overall difference to be significant, $F\ (2, 36) = 7.82$, $p = .002$), and a post hoc test showed that the V-IMTS SVSI group differed significantly from the other two, which did not differ significantly. V-IMTS Soldiers who used the desktop simulators (V-IMTS SVSD, $N = 17$, $M = 1.76$) rated the simulators lower than did another group of Soldiers in 2004 (2004 SVSD, $N = 13$, $M = 1.97$), but this difference was not statistically significant, $F(1,28) = 2.23$, $p = .146$). There are a number of potential reasons why the V-IMTS ratings might have been lower.

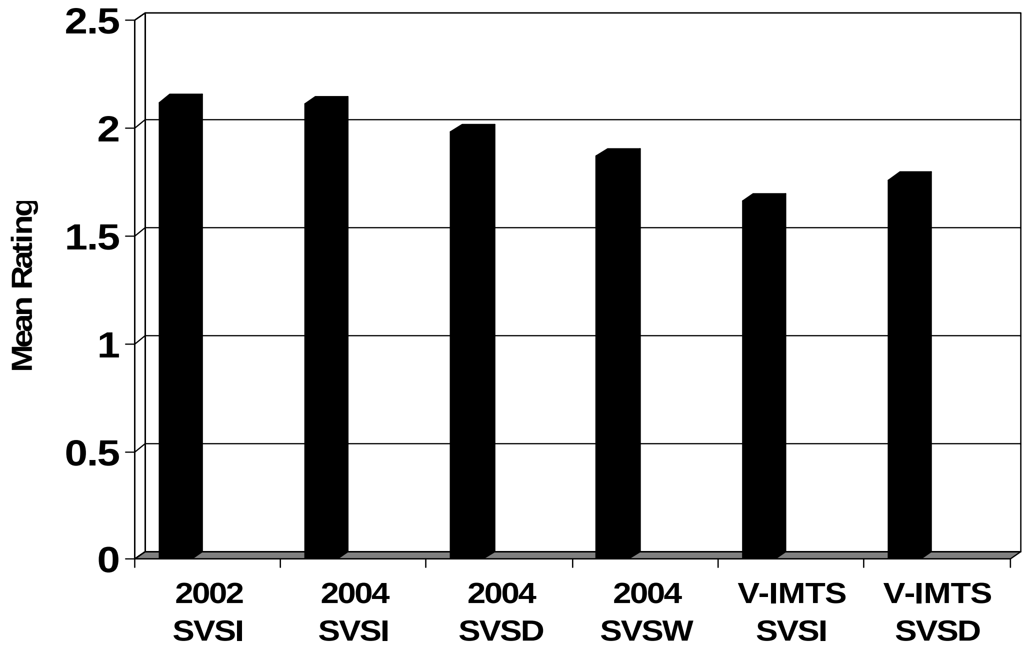

Figure 7. Mean simulator capability ratings for different evaluations.

One potential explanation is that the V-IMTS Soldiers used a higher standard for rating the simulators because they were rating them as a system that was ready for field use, whereas previous groups of Soldiers had rated them as early prototype systems. V-IMTS Soldiers were therefore more critical of problems and difficulties encountered. This would be consistent with the information and instructions that the Soldiers had been given.

A second potential explanation is that the V-IMTS Soldiers were more proficient tactically than any other group, and were therefore more likely to try to push the limits of the simulator capabilities, particularly with regard to precise movement indoors. This is consistent with what we know about the Soldiers' backgrounds. The 2002 Soldiers were intact Scout units who had very little urban combat training or experience. The 2004 Soldiers were ad hoc groups, and while many had served in Iraq, they had no prior experience working together. The V-IMTS Soldiers were intact units with urban combat experience. This explanation is also consistent with the behavior we observed during the scenarios. V-IMTS Soldiers paid considerably more attention to proper stacking and movement techniques inside buildings than did the other groups. This may have made them much more aware of the problem of precise movement.

A third potential explanation was that the V-IMTS Soldiers rated the simulators more critically because they had less practice using them. This is possible, but it is not an entirely satisfactory explanation. The 2002 Soldiers spent an average of 153 minutes conducting scenarios in the simulators, while the V-IMTS Soldiers spent an average of 72 minutes. However, the 2004 Soldiers spent an average of 50 minutes on any one simulator, and had an average of 75 minutes total simulator experience. The differences in the amounts of practice cannot fully explain why the ratings differ.

The most likely explanation is a combination of all three factors.

Recommended Improvements

The number one priority for improvement should be precision movement. Soldiers need to be able to control their movement more precisely, while at the same time moving rapidly, in confined areas such as hallways, stairways, and around corners and while in close proximity to each other. Soldiers must be able to "pie" and "high man/low man" corners. They need to be able to move to their positions within rooms precisely and quickly. As noted above, this is not a simple problem, and will likely require substantial changes to the way collision detection is accomplished, as well as how movement is controlled.

Second, a means needs to be developed to transmit and capture voice communication, both face-to-face and radio. Face–to–face communication should include that between Soldiers and enemies and civilians, as well as within the unit itself.

Third, battlefield sounds need to be represented. The fact that the simulators are in close proximity, with relative positions in the shelter likely to be different from those in the virtual battlefield, suggests that headphones rather than speakers will need to be used. The solution will need to be compatible with the voice communication mechanism as well.

Conclusions

Virtual simulation technology is sufficiently mature to provide a valuable addition to the dismounted Soldier training mix. It can provide additional practice in urban operations to supplement the use of a live MOUT site. The factors it appears to be best suited for training are planning, situation assessment, communication, and coordination.

Primary advantages of virtual simulation, relative to live simulation, are the reduced time that is required to prepare for and conduct an exercise, and the variety of training environments and locations that it can represent.

Major technical challenges remaining are the improvement of precise movement, particularly in confined areas, the representation and recording of radio and face-to-face communications, improved auditory presentation of battlefield sounds, and making the SVS menu system easier to navigate.

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Appendix A

Acronyms

AAR	After Action Review
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
ARI - IFRU	U.S. Army Research Institute for the Behavioral and Social Sciences, Infantry Forces Research Unit
ARI - SSRU	U.S. Army Research Institute for the Behavioral and Social Sciences, Simulator Systems Research Unit
ARL – CISD	U.S. Army Research Laboratory, Computational and Information Sciences Directorate
ARL – HRED	U.S. Army Research Laboratory, Human Research and Engineering Directorate
ARTEP	Army Training and Evaluation Program
CATT	Combined Arms Tactical Trainer
DACP	Defense Acquisition Challenge Program
DI	Dismounted Infantry
DISAF	Dismounted Infantry Semi-Automated Forces
DOD	Department of Defense
DIS	Distributed Interactive Simulation
DIVAARS	Dismounted Infantry Virtual After Action Review System
DWN	Dismounted Warrior Network
DWN ERT	Dismounted Warrior Network Enhancements for Restricted Terrain
IC	Individual Combatant
I-MTS	Integrated MOUT Training System
I-Port	Individual Portal
IST	University of Central Florida, Institute for Simulation and Training
MES	Multiple Elevation Structures
MOS	Military Occupational Specialty
MOUT	Military Operations in Urban Terrain
OneSAF	One Semi-Automated Forces
OPFOR	Opposing Forces
OTBSAF	OneSAF Test Bed Semi-Automated Forces
PC	Personal Computer
RDECOM	U.S. Army Research, Development, and Engineering Command
SAF	Semi-Automated Forces
STO	Science and Technology Directorate
STTC	Simulation and Training Technology Center
STRICOM	U.S. Army Simulation, Training, and Instrumentation Command
STX	Situational Training Exercise
SVS	Soldier Visualization System
SVSD	Soldier Visualization System Desktop
SVSI	Soldier Visualization System Immersive
TPIO	TRADOC Program Integration Office
TRADOC	U.S. Army Training and Doctrine Command
TSP	Training Support Package

VE	Virtual Environment
VERTS	Virtual Emergency Response Training System
V-IMTS	Virtual Integrated MOUT Training System
VTX	Virtual Training Exercise

Appendix B

V-IMTS Assessment Questionnaires

Table of Contents

Questionnaire Page

Biographical Information Questionnaire

ID___________________________

Date__________________

Please fill in the blank or mark or circle the appropriate response.

1. What is your age? _____ Years 2. MOS _______ 3. Rank ________

4. Time in service: Years _____ Months _____

5. What is your current duty position? ___________________

How long in this position? __________

6. What Army training courses have you completed? Check all that apply.

____ OSUT/AIT	_____ PLDC	_____BNCOC
____ BFV Leader Course	_____ Airborne	_____ Combat Life Saver Course
____ Air Assault	_____ Ranger	_____ Other (specify)

7. How susceptible to motion or car sickness do you feel you are?

1	2	3	4	5	6	7
very mildly			average			very highly

8. Do you have normal or corrected to normal 20/20 vision? Yes No

9. Are you color blind? Yes No

10. Are you ___ right handed? ___ left handed?

11. How would you describe your level of confidence in using computers?

1	2	3	4	5
low		average		high

12. How many hours per week do you use computers? _____ hours per week

13. How many hours per week do you play computer or video games (X-Box, Playstation, etc.)? _____ hours per week

14. How often have you trained at a MOUT site since basic training (***NOT*** including demonstrations)?

___ not since basic training ___ 1-3 times ___ more than 3 times

15. Have you ever participated in close quarter combat (room clearing) training?

Yes No

16. Have you had any <u>other</u> experience with military computer simulations?

Yes No

If yes, please describe briefly or give the names of the simulators.

17. Did you serve in Iraq or Afghanistan?

Yes No

Soldier Questionnaire Part I: Simulator Capability

ID Number:__________________________ Today's Date:_____________________

Section I. Simulator Capabilities

Please rate your ability to perform each task in the virtual simulator

	Did Not Attempt	Very Good	Good	Poor	Very Poor
1. Move through open areas as a widely separated group.					
2. Move according to directions.					
3. Maneuver around obstacles.					
4. Move in single file.					
5. Maneuver below windows.					
6. Maneuver close to others.					
7. Determine other team/squad members' positions.					
8. Maintain position relative to other team/squad members.					
9. Maneuver around corners.					
10. Locate assigned areas of observation, e.g. across the street.					
11. Look around corners.					
12. Visually locate the source of enemy fire.					
13. Determine the source of enemy fire by sound.					
14. Distinguish between friendly and enemy fire.					
15. Identify civilians.					
16. Communicate enemy location to team member.					
17. Take hasty defensive positions.					
18. Aim weapon.					
19. Fire weapon in short bursts.					
20. Fire weapon accurately.					
21. Identify covered and concealed routes.					
22. Identify areas that mask supporting fires.					
23. Coordinate with other squad members.					
24. Execute the assault as planned.					
25. Move quickly to the point of attack.					
26. Assume defensive positions.					
27. Identify safe and danger areas.					
28. Locate support team positions.					
29. Locate fire team buddy positions.					
30. Take position to one side of the doorway.					
31. Move quickly through doorways.					
32. Take a tactical position while within a room.					
33. Scan the room quickly for hostile combatants.					
34. Engage targets within a room.					

Soldier Questionnaire Part I: Simulator Capability (Continued)

Please rate your ability to perform each task in the virtual simulator.

	Did Not Attempt	Very Good	Good	Poor	Very Poor
35. Identify non-combatants within a room.					
36. Move past furniture in a room.					
37. Maneuver past other personnel in a room.					
38. Understand verbal commands.					
39. Identify sector of responsibility.					
40. Communicate SPOT reports to squad leader.					
41. Execute planned route.					
42. Identify assigned sectors of observation.					
43. Move close to walls.					
44. Scan from side-to-side.					
45. Scan up and down.					
46. Identify enemy Soldiers.					
47. Estimate distances from self to a distant object.					
48. Climb up or down stairs.					
49. Locate enemy Soldiers inside buildings firing at your unit.					
50. Determine the direction enemy rounds are coming from.					
51. Use fragmentation grenades.					
52. Use hand-held illumination (flares).					
53. Use flash-bang grenades.					
54. Use tactical hand-held smoke grenades.					

Soldier Questionnaire Part II: After Action Review (AAR)					
Please indicate how much you agree or disagree with each of the following statements by placing a check mark in the appropriate cell. **Answer questions 1 through 8 with regard to the AARs conducted for the live exercises.**					
	Strongly Agree	**Agree**	**Neither Agree nor Disagree**	**Disagree**	**Strongly Disagree**
1. The AAR system was effective in displaying movement outside of buildings.					
2. The AAR system was effective in displaying movement inside of buildings.					
3. The AAR system was effective in replaying communications.					
4. The AAR system made it easy to determine what happened during a mission.					
5. The AAR system made it easy to determine why things happened the way they did during a mission.					
6. The AAR system made it easy to determine how to do better in accomplishing the mission.					
7. The AAR system made it easy to determine the order in which key events occurred during the mission.					
8. The AAR system was more effective than conducting an AAR without any visual or audio playback (just talking).					
Answer questions 9 through 16 with regard to the AARs conducted for the virtual exercises.					
	Strongly Agree	**Agree**	**Neither Agree nor Disagree**	**Disagree**	**Strongly Disagree**
9. The AAR system was effective in displaying movement outside of buildings.					
10. The AAR system was effective in displaying movement inside of buildings.					
11. The AAR system was effective in replaying communications.					
12. The AAR system made it easy to determine what happened during a mission.					
13. The AAR system made it easy to determine why things happened the way they did during a mission.					
14. The AAR system made it easy to determine how to do better in accomplishing the mission.					

Soldier Questionnaire Part II: After Action Review (AAR) (continued)					
	Strongly Agree	**Agree**	**Neither Agree nor Disagree**	**Disagree**	**Strongly Disagree**
15. The AAR system made it easy to determine the order in which key events occurred during the mission.					
16. The AAR system was more effective than conducting an AAR without any visual or audio playback (just talking).					

Soldier Questionnaire Part III:Training Effectiveness

ID Number: ______________________ **Today's Date:** __________________

Position Held During Today's Exercise (*Check one*):

______ **Squad Leader**
______ **Alpha Team Leader**
______ **Bravo Team Leader**
______ **Team Member**

As a result of today's exercises, my ability to perform the following tasks was changed as follows.	No Improvement	Slight Improvement	Moderate Improvement	Vast Improvement
1. React to Contact Battle Drill.				
2. Assess the tactical situation.				
3. Control of squad/fire team movement during the assault.				
4. Locate known or suspected enemy positions.				
5. Clear a room.				
6. Clear a building.				
7. Control squad or fire team movement while ***NOT*** in contact with the enemy.				
8. Plan a tactical operation.				
9. Control your squad or fire team.				
10. Coordinate activities with your chain of command.				
11. Communicate with members of your team or squad.				

Date______________ **ID_______________________**
Time_____________

Symptom Checklist

Instructions: Please indicate the severity of symptoms that apply to you right now by circling the appropriate word.

1. General discomfort	None	Slight	Moderate	Severe
2. Fatigue	None	Slight	Moderate	Severe
3. Headache	None	Slight	Moderate	Severe
4. Eye Strain	None	Slight	Moderate	Severe
5. Difficulty focusing	None	Slight	Moderate	Severe
6. Salivation increased	None	Slight	Moderate	Severe
7. a. Warm Sweating (from temperature or exertion)	None	Slight	Moderate	Severe
b. Cold Sweating (from discomfort or nervousness)	None	Slight	Moderate	Severe
8. Nausea	None	Slight	Moderate	Severe
9. Difficulty concentrating	None	Slight	Moderate	Severe
10. "Fullness of the Head"	None	Slight	Moderate	Severe
11. Blurred Vision	None	Slight	Moderate	Severe
12. a. Dizziness with eyes open	None	Slight	Moderate	Severe
b. Dizziness with eyes closed	None	Slight	Moderate	Severe
13. Vertigo	None	Slight	Moderate	Severe
14. *Stomach awareness	None	Slight	Moderate	Severe
15. Burping	None	Slight	Moderate	Severe

16. Other (describe): ____
____

* Stomach awareness is usually used to indicate a feeling of discomfort, which is just short of nausea.

Post-Experimental Group Interview

Group Interviewed

_____ **Leader (Squad Leader, Alpha Team Leader, and Bravo Team Leader)**

_____ **Soldier**

_____ **Other (Describe)**____

Interviewer____________________ **Date:**_____________

1. Do you think that the virtual simulators you used yesterday and today were a useful training tool (that is, did you learn from your experience)?

What did you learn?

2. Do you think that the virtual training helped your performance in the live MOUT site?

Do you think that it would help your performance in actual combat?

3. Where in the Army training system do you think that this type of training would be most appropriate or useful?

4. What did you like most about the virtual simulators?

5. What did you like least about the virtual simulators?

6. What did you like most about the scenarios?

7. What did you like least about the scenarios?

8. Could these scenarios be used to practice decision-making skills?

Why or why not?

9. Were the After Action Reviews (AARs) provided after the exercises helpful?

Why or why not?

10. What were the best aspects of the live AARs?

11. What were the worst aspects of the live AARs?

12. Are their additional capabilities that you think the live AAR system should have?

13. What were the best aspects of the virtual AARs?

14. What were the worst aspects of the virtual AARs?

15. Are their additional capabilities that you think the virtual AAR system should have?

16. What part of the simulation (tasks, terrain, etc.) was the most realistic?

17. What part of the simulation (tasks, terrain, etc.) was the least realistic?

18. What were the most difficult tasks to perform in the simulators?

19. Did you find any aspects of the simulator or simulation distracting?

If so, what?

20. Did you receive enough training on the use of the simulators, or do you think you needed more?